AD-A239 321

'ENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE February, 1991	3. REPORT TYPE AND DATES COVERED THESIS/~~DISSERTATION~~

4. TITLE AND SUBTITLE Estimation of Blood Loss: Comparing the Accuracy of Operating Room Personnel	5. FUNDING NUMBERS
6. AUTHOR(S) Robert D. Northern, Jr., Captain	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AFIT Student Attending: University of New York	8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/CI/CIA-91-011
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFIT/CI Wright-Patterson AFB OH 45433-6583	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for Public Release IAW 190-1 Distributed Unlimited ERNEST A. HAYGOOD, 1st Lt, USAF Executive Officer	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

91 ... 072

91-07352

14. SUBJECT TERMS	15. NUMBER OF PAGES 60
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

ESTIMATION OF BLOOD LOSS:
COMPARING THE ACCURACY OF OPERATING ROOM PERSONNEL

by

Robert D. Northern, Jr.

A project submitted to the
Faculty of the Graduate School of
State University of New York at Buffalo
in partial fulfillment of the requirements
for the degree of
Master of Science

February, 1991

MASTER'S PROJECT APPROVAL FORM

STATE UNIVERSITY OF NEW YORK AT BUFFALO
SCHOOL OF NURSING

This is to certify that Robert D. Northern, Jr., in the Graduate Program, School of Nursing, has successfully completed his research project entitled, Estimation of Blood Loss: Comparing the Accuracy of Operating Room Personnel, in partial fulfillment of the requirements for the degree of Master of Science.

Signature of: ______________________
Thomas E. Obst
(Committee Chair)

____
Nadine Fallacaro
(Committee Member)

Date: February, 1991

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to: Thomas Obst, CRNA, MS, for his time and suggestions to the construction of this paper; Nadine Fallacaro, CRNA, MS, for her contributions to the actual conduct of this study, and the physiological base of this paper; Barbara Zon, for her continued encouragement; and most of all to my wife Mimi, and my boys Luke, Jeb, and Jake, for their understanding love and support over the last two years.

TABLE OF CONTENTS

LIST of TABLES & FIGURES

CHAPTER I

Introduction to the Research Problem

The transfusion of blood is a critical decision which is many times based upon the estimation of the blood loss by the anesthetist, however no blood transfusion is without risk to the recipient. Among the serious risks of blood transfusion, viral hepatitis is the most common. Clinical icteric hepatitis is quite uncommon after transfusion, but until recently 5-6% of all blood recipients (the usual recipient receives 3-4 units) developed subclinical anicteric posttransfusion hepatitis, which was documented by abnormal liver function tests and liver biopsy. Only about 10-20% of these cases resulted from the hepatitis B virus. Eighty to 90% were from non-A, non-B hepatitis. Chronic hepatitis followed in about half of these patients with non-A non-B, and in approximately 10%, cirrhosis developed. Since the testing of donor units for non-A and non-B virus markers (hepatitis core antibody and alanine transaminase) has been implemented, the risk of posttransfusion viral hepatitis has decreased to one per 200 units of transfused blood, or 1-2% of patients (Walker, 1987).

Acute hemolytic transfusion reactions usually result from a clerical error, resulting in ABO incompatibility, which leads to intravascular hemolysis of the donor's cells.

Immediate hemoglobinemia and hemoglobinuria follow. The reaction often results in disseminated intravascular coagulation. The risk for acute hemolytic transfusion reaction is one in 25,000, or 0.004% (Walker, 1987).

The risk of acquired immune deficiency syndrome (AIDS) is of paramount concern for transfusion candidates. The risk however, has declined as the direct result of the 1985 implementation of donor screening for the antibody to human immunodeficiency virus (anti-HIV). This antibody however, may not be detectable in blood donors who are infected with AIDS and have not yet seroconverted (developed the antibody), the duration of this window period is controversial. The mean period of time between transfusion and diagnosis of AIDS for adults is three years, with a range of one to seven years. The risk for transfusion-associated AIDS is between one in 20,000 and one in 1,000,000 units of blood transfused with an average incidence of one in 156,000 transfusions (Walker, 1987, Goodnough & Shuck, 1990).

Many other adverse effects of blood transfusions can occur, including bacterial infections, malaria, allergic reactions, acute lung injury, depression of erythropoiesis, leukocyte alloimmunization, and red blood cell alloimmunization. Approximately 20% of all transfusions result in some adverse effects to the recipient (Walker, 1987, National institute of Health, 1987).

Between 1971 and 1980 the use of blood for transfusions doubled (Surgenor, 1988). There were several reasons for this trend. First, an adequate supply of blood was available. Secondly, a screening test for hepatitis B surface antigen was in place. Lastly, it is believed that the conversion to an all volunteer blood donor base had made the national blood resource safer. These differences substantially lowered the risk of hepatitis B transmission by blood transfusion and contributed to a feeling that blood transfusion was an almost completely benign procedure.

The awareness of AIDS changed both public and clinician perception about the safety of blood transfusion (Sherman, 1988). Between 1982 and 1985, total red blood cell transfusion rates either declined or leveled off from the previous patterns of growth rate (Surgenor, 1988). Various other factors may be implicated in this change as well. For example, decreased availability of banked blood may have been associated with altered patterns of blood use. Many donors felt that giving blood could infect them with AIDS, and this is blamed for a slight decline in donations. However, Surgenor (1988) found no evidence that the large changes in the number of transfusions were more than transiently affected by local shortages of donor blood.

The estimation of surgical blood loss by the medical team is one assessment upon which the decision to replace blood is made. There are many methods for quantifying blood loss. Such methods include colorimetric (Gatch & Little, 1924, Rustad, 1963), gravimetric (Wangensteen, 1942), electroconductive (LeVeen & Rubricas, 1958), isotopic (Williams & Fine, 1961), and calculative techniques (Ha, 1986), all of which demonstrate some error in determination. This error has been shown to be significantly less than the subjective methods. These methods, however, prove to be time consuming, cumbersome, and not practical for operating room use. Visual estimation of the volume of blood loss is the technique used in most surgical settings.

Many clinicians base their blood replacement therapy on the patient's hematocrit. Estimated blood loss based solely on the hematocrit may be inaccurate and is not a reliable reflection of true blood loss. Hemorrhage induces a mobilization of extravascular fluid into the vascular compartment. This is due to changes of the hydrostatic pressure within the capillaries. The capillary hydrostatic pressure decreases and reabsorption of extravascular fluid occurs as predicted by the Starling forces. Initially, refilling of the plasma volume from extracellular fluid is reflected by decreasing hematocrit values. This mechanism of transcapillary migration may be able to restore the plasma volume if time is adequate for this redistribution. There is a time lag of about 4-6 hours until the hematocrit significantly decreases. Thus, hematocrit values may not be indicative of the status of the blood volume (Wilson, 1972).

A decrease in the hematocrit, reflecting a reduced concentration of red blood cells, does not always reflect blood loss, but may reflect overhydration instead. It usually takes 6-48 hours after an acute hemorrhage for the blood volume to be fully restored to normal by interstitial fluid transfer. If large volumes of crystalloid or colloid fluid have been administered, a progressive fall in the hematocrit values may be observed as a result of hemodilution by the resuscitative fluids. The hematocrit may continue to fall (in spite of discontinued blood loss) for 24-48 hours as further dilution of the remaining red blood cells continues from extracellular and intracellular fluid shifts (Comeau, 1983).

The fall in hematocrit after hemodilution will generally give some idea as to how much blood was lost. Thus, if the hematocrit fell from 50% to 40% 48 hours after an acute hemorrhage, one can assume that about 20% of the blood volume has been lost (Wilson, 1973).

In 1939, Nadal suggested that patients who lost between 15-20% or more of their total estimated blood volume (EBV) frequently went into peripheral circulatory failure. More recently Condon (1972) specifically outlined the physiologic effects that were exhibited by patients who have suffered different stages of blood loss. The stages of blood loss are divided into four categories primarily based upon clinical symptoms; minor (less than 15% of the EBV);

moderate (20% - 30% of the EBV); major (35% - 40% of the EBV); and severe (45% of the EBV). One can calculate EBV in a normal adult male patient by multiplying the patient's weight in kilograms (kg) by 70, this will give you the EBV in milliliters (ml) of blood (Firestone, 1988). For example, the EBV for a 70 Kg adult male is 4900 ml. In this 70 kg patient, a miror blood loss will rarely induce a vasovagal syncope. If the same patient, has a moderate loss he may experience a decrease in pulse pressure, tachycardia, tachypnea, and postural hypotension. A major blood loss may constitute hemorrhagic shock with a drop in systolic pressure, cold clammy skin, and a decrease of urinary output of less than 30 ml per hour. If this 70 kg patient incurred a blood loss of more than 2000 ml (which would be considered a major blood loss), hypoxia will result and the patient may be unresponsive to fluid resuscitation efforts (Condon 1972). One should realize that in this particular example these parameters apply to a patient that has not had adequate volume replacement.

As mentioned above, acute blood loss may lead to hypovolemic shock. The clinical manifestations of shock include pallor, cyanosis, sweating, disorientation, tachycardia, cardiac dysrhythmias, pump failure, tachypnea, increased wasted ventilation, venous admixture, low cardiac output, hypotension, oliguria, sludging of blood disseminated intravascular coagulation, and acidosis.

The body's normal physiologic homeostatic responses are geared to prevent severe hypotension that may lead to decreased vital organ perfusion. These adaptive mechanisms are the neuroendocrine and cardiovascular systems. As hemorrhage ensues the renin-angiotensin-aldosterone system is activated, this leads to sodium and water absorption in the distal tubules, the collecting tubule, and collecting duct in the nephrons. This can increase the extracellular fluid volume to as high as 10-20% above normal. Antidiuretic hormone secretion is elevated which constricts the peripheral arteries and veins and also greatly increases water retention by the kidneys. The activation of the sympathetic nervous system releases endogenous catecholamines. The cardiovascular response attempts to maintain adequate perfusion to the vital organs. Tachycardia and arteriolar vasoconstriction, can in some situations, maintain blood pressure until about 30-40% of the blood volume has been lost. Thus a patient may be severely hypovolemic, yet have a reasonably normal blood pressure. The degree of this response is proportional to the amount of blood loss. Losses of greater than 30-40% of the vascular volume can produce an acute insult on major organ systems. Myocardial, cerebral, and renal function are endangered by the presence of persistent hypotension and shock states (Zaglaniczny, 1988, Priano, 1989).

The assessment of pulse rate, blood pressure, skin color, and temperature should be considered first, but there is no single clinical sign of impending shock due to blood loss, especially in the anesthetized patient (MacLeod, 1966). If more than 20% of the patient's EBV is lost, replacement should be provided at a rate which equals the loss (Miller, 1986). The nurse anesthetist is responsible for the determination and replacement of blood loss during surgery. Ideally, blood loss during surgery should be continuously and accurately measured.

The majority (55%) of blood loss during surgery is absorbed by gauze and sponges. Twenty five percent is lost in suction canisters, and about 20% has been shown to be lost in the drapes, surgical gowns, footwear, operating table, equipment, and the floor (Brockner & Donvig, 1969). In most operating rooms these sponges and gauze are removed from the operative field by the operating room (O.R.) staff and displayed for observation by the anesthesia and surgical personnel for subjective estimation of blood loss. A considerable amount of blood collected on these sponges becomes coagulated and dries up, thus increasing the margin for error.

Subjective estimation of blood loss by the surgical team has often been shown to be grossly inaccurate and varies significantly among individuals. These errors may have serious consequences in terms of the patients' condition, especially for poor risk patients (Bonica & Lyter, 1951).

Literature Review

The measurement of blood loss during surgical operations is a routine and necessary procedure, especially with high risk patients. Gatch and Little (1924) were the first to report the measurement of blood loss during some of the more common types of operations in general surgery. They used the acid hematin method which involves washing all of the sponges, linen, and instruments free of blood and then adding hydrochloric acid. They commented on the large loss of blood during certain operations, particularly radical mastectomy in which seemingly there was no excessive bleeding at any time during the procedure. In discussing his experience with 3,000 transfusions, Blain (1929) emphasized that the amount of blood lost during operations is often several times greater than that estimated by the surgeon. He urged the preoperative correction of anemia with the immediate replacement of blood loss during surgery. He also condemned the procrastination of some surgeons in the delay of giving transfusions until after shock had occurred. Coller and Maddock (1932) reported their observations in measuring blood loss in eighteen surgeries and concluded that the amount lost was greater than they had subjectively estimated.

Brockner and Donvig (1969) studied the subjective estimation of blood loss against electronic determination.

They concluded that visual evaluation provides blood loss estimates that were lower than those obtained via electronic techniques. They emphasized the importance of the blood contained in the drapes and swabs.

Wallace (1967) studied blood loss with 835 obstetric patients and stated that using visual assessment was misleading because blood was always underestimated. Moir and Wallace (1967) used the hemoglobin dilution technique and compared visual estimation of blood loss in 214 patients and found that visual estimation was much lower than the blood loss determined by hemoglobin dilution technique.

Using the colorimetric method for determining the actual amount of blood loss, (error of +/- 5%), Delikan (1972) compared the subjective estimates by surgeons and anesthesiologists of operative blood loss. Surgeons were significantly less reliable than anesthesiologists in estimating blood loss. He did not attempt to correlate the years of experience and educational factors in this study.

Higgins (1982) measured the ability of nurses to accurately estimate blood loss. This study was designed in a simulated blood loss situation. The investigator used outdated human blood for the study and was able to measure the exact volume of blood to be estimated, and displayed it in an observable environment for the subjects to estimate. The amount of blood to be estimated was predetermined by the investigator. Since the investigator was able to control and manipulate the amount of blood to be estimated (unlike the previous studies mentioned above), the margin of error was deleted. She concluded that there was a significant difference between the range of estimates and the actual amount of blood on gauze. She stated that 71% of the nurses overestimated, and 25% underestimated the actual amount of blood, regardless of education, clinical experience, and specialty areas.

This study compared the estimations of blood loss by anesthesia providers, surgeons, and operating room nurses to determine if relationships and differences exist. The in vitro (simulation) technique allowed the investigator to control and manipulate the actual amount of blood, and then analyzed the effect of level of education and years of clinical experience on the subjects' ability to estimate blood loss.

Subjective estimation by visual assessment of the operating room environment and by using the amount of fluid in the suction containers has the advantage of being inexpensive, rapid, and continuous. The literature indicates that visual estimation is extremely uncertain and should not be relied upon as the only parameter in determining blood loss. As indicated in the literature, the clinician should use all clinical observations such as pulse, blood pressure, pulse pressure, central venous pressure, hematocrit, hemoglobin, skin color, capillary refill, and any other clinical signs that may help to determine intraoperative blood loss.

Purpose

The purpose of this study is to compare the accuracy of anesthesia personnel, surgeons, and operating room nurses in estimating blood loss (at various levels) by visual subjective estimations. Furthermore, an attempt will be made to delineate extraneous variables which may account for the differences in estimation ability. These extraneous variables include level of education, and years of clinical experience.

Research Question

Do anesthesia personnel, surgeons, and operating room nurses differ in their ability to estimate blood loss?

Hypothesis

Anesthesia personnel, surgeons, and operating room nurses will demonstrate a difference in their ability to estimate blood loss.

CHAPTER II

Methodology

Overview of Research Design

This study examined possible differences in blood loss estimates that exist among three groups of operating room personnel. A non-experimental design was utilized with a convenience sample (see section on sampling). There were three groups:

Group 1) - anesthesia personnel (physician and nurse anesthetists)

Group 2) - surgeons

Group 3) - operating room nurses

Subjects from all groups entered three simulated operating room stations prepared by the investigator. Each station had a predetermined amount of blood. The blood was distributed among operating room drapes, raytex gauze, laparotomy sponges, surgical towels, and suction canisters. A different amount of blood was present at each station to simulate various intraoperative conditions. The subjects visually assessed and reported their estimations of the amount of blood present. Their level of education and their amount of clinical experience were also noted.

Safety measures were taken by the investigator to avoid contact with the blood. During the preparation of the display area, the investigator wore goggles, a surgical gown, protective hat and shoe covers. Arrangements were made with the operating room housekeeping department to clean the stations at the end of the study and dispose of all waste material as they normally do between actual surgical cases. Additionally, the subjects were not allowed to touch any of the materials used during the study, and were not allowed to come within 5 feet of the display.

Arrangements for acquiring the blood were made with the American Red Cross. An account was established by the investigator and the American Red Cross of Rochester, N.Y. to purchase normally screened and processed donated human blood. The donated blood was more than 21 days old and outdated for infusion. Whole blood was used because it, unlike packed red blood cells, closely resembles blood loss that occurs during surgery.

<u>Control of Variables</u>

The actual amount of blood at each simulated station was predetermined by the investigator. The actual amount was measured by the investigator in ml using a syringe and graduated canister to apply a specific amount of blood on raytex gauze, laparotomy sponges, operating room drapes, operating room towels, and in suction canisters. Three different stations were utilized. Each station was set up on a draped table with a three by six feet top surface. Each station represented a specific amount of blood loss. Station one represented a 600 ml blood loss; station two represented a 3400 ml blood loss; and station three represented a 1400 ml blood loss. These amounts typify levels of minor, severe, and moderate surgical blood loss respectively. The subjects were unaware of these ranges and were not told of the results until after all data had been collected. The number of sponges, suction canisters, and surgical towels used at each station were relative to the amount of actual blood present to simulate a realistic picture of surgery.

A premeasured amount of normal saline (commonly utilized as irrigation fluid) was added to each station, some in the gauze, some in the sponges, some in the towels, and some in the suction canisters, again to simulate an actual surgery. The amount of saline added was disclosed to the experimental subjects as they entered the stations. This information is available to operating room personnel during the normal course of a surgery.

At station number one, the investigator distributed 600 ml of blood among 10 laparotomy sponges, 20 raytex gauze, and into one, 2 liter suction canister. The amount of normal saline added was 1550 ml. At station number two, 3450 ml of blood was distributed among 50 laparotomy sponges, 50 raytex gauze, four surgical towels, and into three, 2 liter suction canisters. The amount of normal saline added to this station was 3100 ml. At station number three 1400 ml of blood was distributed among 20 laparotomy sponges, 30 raytex gauze, four surgical towels, and two, 2 liter suction canisters. The amount of normal saline added was 3000 ml (table 1).

TABLE 1
Distribution of Blood and Supplies

	whole blood (ml)	saline (ml)	sponges gauze	# suction canisters
Station 1	600	1550	10 laps 20 raytex	1
Station 2	3450	3100	50 laps 50 raytex 4 towels	3
Station 3	1400	3000	20 laps 30 raytex 4 towels	2

The subjects entered the room equipped with only a pencil and a data sheet on a clip board. They were allowed to visually assess the room and were not allowed to touch the display stations. Subjects maintained a distance of five feet from the display and were not permitted to cross a boundary line. The subjects were each allotted a five minute time period to make their estimations. At the end of their estimation or after the five minute time period, subjects reported their estimations and returned their data sheet to the investigator. The investigator acted as the proctor during the experiment and did not speak, except to stop the subject at the end of the specified time. The subjects were asked not to share their estimations with other subjects in order to decrease the chance of biased estimations.

Setting

The operating room suite at Erie County Medical Center, Buffalo, New York was used. Arrangements were made with the Operating Room Nursing Supervisor and the Director of Anesthesia and Operating Room Services to reserve an unutilized room for the day of the experiment. The experimental period was on June 14, 1990, from 8:30 AM to 12:00 PM.

The drapes, gauze, sponges, and suction containers utilized in each experiment were the paper/disposable type. The lighting and temperature at each operating room station remained constant for the entire data collection period.

Sample

The accessible population consisted of operating room personnel present at the hospital on the day of the study. Volunteers were sought among anesthesia providers, surgeons, and operating room nurses. The principal determinant of the sample size was the number of volunteers who were eligible and present for the study; however, a minimum sample of ten subjects in each group was selected. A total of 50 subjects participated in the study. Eighteen (36%) were in the anesthesia group, seventeen (34%) were surgeons, and fifteen (30%) were operating room nurses.

Data Collection

Data was collected at the end of each subject's estimation. Each subject submitted data on the type of questionnaire in appendix B.

The independent variable and the covariates were organized as such:

Group

A) Anesthesia personnel

B) Surgeon

C) Operating room personnel

Covariates

1) Level of education (highest degree obtained)

A)	High school	E)	Master's
B)	Diploma	F)	Doctorate
C)	Associate	G)	Medical
D)	Baccalaureate	H)	Other

2) Years of clinical experience in an operating room

A) 1 - 2

B) 3 - 5

C) 6 - 10

D) 11- 20

E) greater than 20

CHAPTER III

Statistical Methods & Data Analysis

Variables

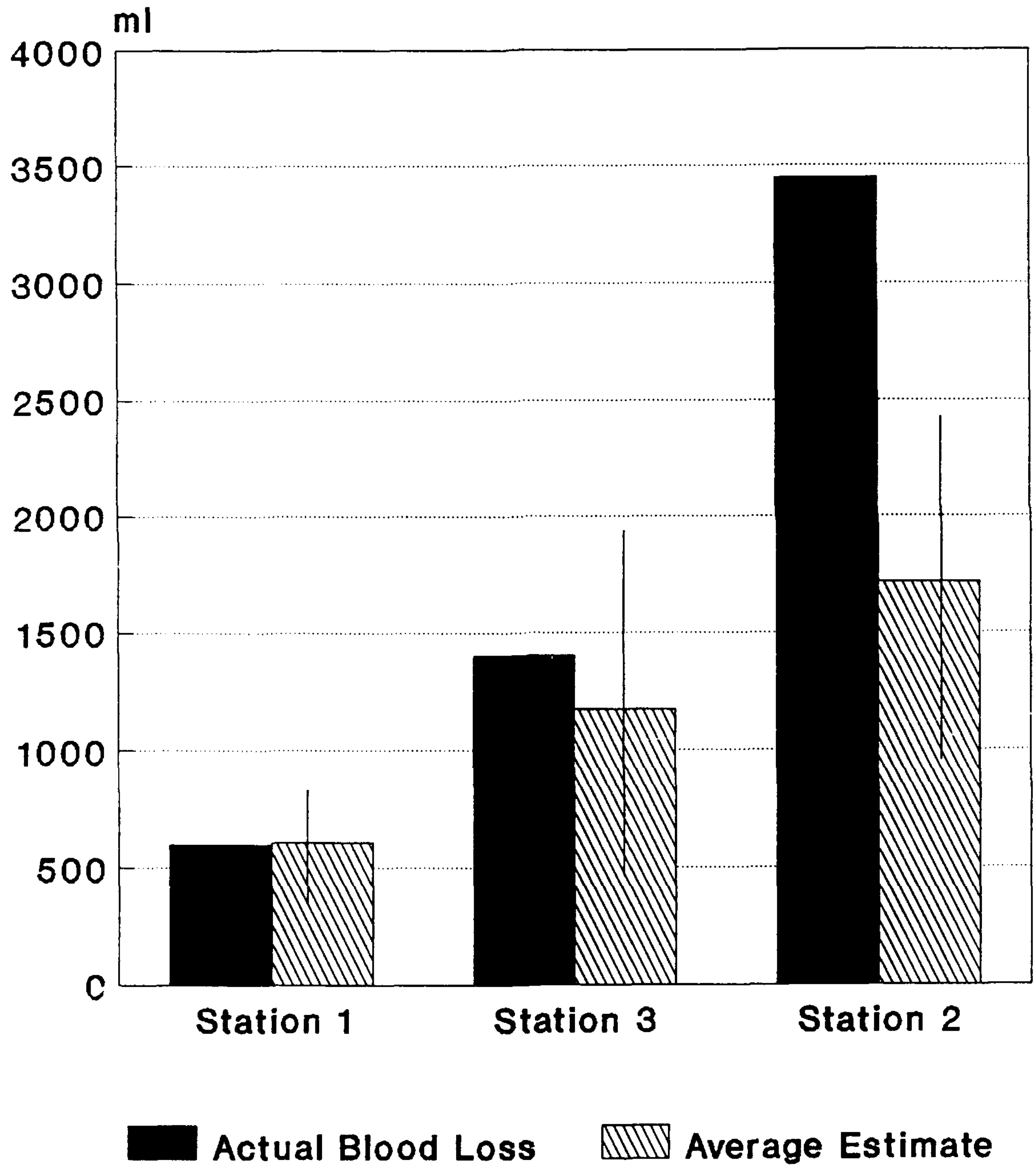
The independent variable is the specialty group to which the subjects belong, ie. anesthesia personnel, surgery, or operating room nurses. The dependent variable is their accuracy in estimating the volume of blood loss. The measurements of these variables are displayed in appendix 'A' (conceptual and operational definitions).

Description

Of the 50 subjects 36% (n=18) were in the anesthesia group, 34% (n=17) were surgeons, and 30% (n=15) were operating room nurses. Figure 1 provides a description of the overall general frequencies and distributions which are not stratified by specialty groups. At station one, where the actual amount of blood was 600 ml, the estimates ranged from 200 ml to 1250 ml with a mean of 608 ml, and a standard deviation of 226 ml. The subjects' errors ranged from 0 ml to 650 ml, with a mean of 176 ml, and a standard deviation of 138 ml. Forty-six percent (n=23) of the subjects overestimated while 48% (n=24) underestimated, and 6% (n=3) were exact with their estimates. At station two, where the actual amount of blood was 3450 ml, the estimates ranged from 700 ml to 3575 ml with a mean of 1717 ml, and a standard deviation of 756 ml. The subjects' errors at station two ranged from 50 ml to 2750 ml, with a mean of 1736 ml, and a standard deviation of 736 ml. Four percent (n=2) of the subjects overestimated while 96% (n=48) underestimated. At station three, where the actual amount of blood was 1400 ml, the estimates ranged from 150 ml to 3750 ml, with a mean of 1170 ml, and a standard deviation of 738 ml. The subjects' errors at station three ranged from five ml to 2350 ml, with a mean of 645 ml, and a standard deviation of 418 ml. Thirty-four percent (n=17) overestimated while 66% (n=33) underestimated.

The total error of each subject was calculated by adding together the errors at each station for each subject. They ranged from 251 ml to 4050 ml, with a mean of 2558 ml, and a standard deviation of 885 ml. Of the 150 total estimates made by all the subjects, 2% (n=3) were exact, 28% (n=42) were overestimates, and 70% (n=105) were underestimates.

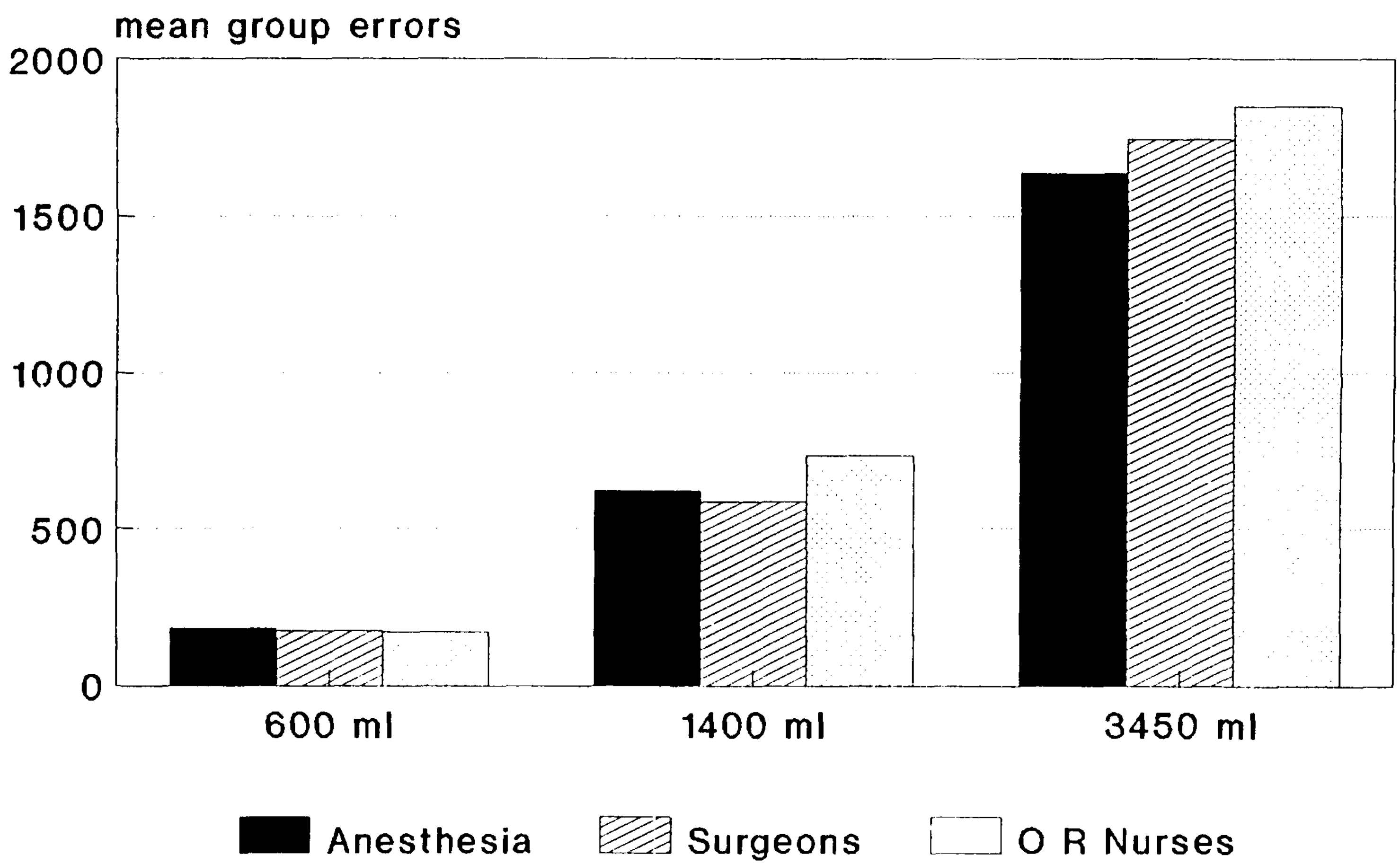
FIGURE 1 Means and Distributions of All Estimates at Each Station



<u>Comparing group means</u>

The individual differences of the estimated blood loss were compared with the actual amount of blood. From these individual differences, group means were calculated and analyzed for differences. The means closer to the actual amount of blood were regarded as more accurate, whether it was more than or less than the actual amount. All estimates were in ml. The mean estimations of the independent groups were analyzed against each other using ANOVA. Figure 2 shows the similarity at each level of blood loss among all provider groups.

FIGURE 2 Mean Group Errors At Each Station



At station #1 the mean error of estimates by the anesthesia group was 181.17 ml (table 2), compared to 176.76 ml for the surgeons, and 170.33 ml for the operating room nurses. The errors in estimates did not differ significantly between the groups (p=.976).

TABLE 2
Summary of ANOVA Between Specialty Groups
on Accuracy of Estimating Blood Loss
at Station #1

Group	number of subjects	mean	standard deviation		
Anesthesia	18	181.17	156.62		
Surgeons	17	176.76	141.83		
O.R. Nurses	15	170.33	119.02		
Source	df	SS	MS	F	p
Between groups	2	963.29	481.64	.024	.976
Within groups	47	937186.89	19940.15		

At station #2 the mean error of estimates by the anesthesia group was 1636.11 ml (table 3), compared to 1744.12 ml for the surgeon group, and 1848.00 ml for the O.R nurse group. The errors in estimates did not differ significantly between the groups (p=.720).

TABLE 3
Summary of ANOVA Between Specialty Groups on Accuracy of Estimating Blood Loss at Station #2

Group	number of subjects	mean	standard deviation		
Anesthesia	18	1636.11	831.51		
Surgeons	17	1744.12	671.49		
O.R Nurses	15	1848.00	716.13		
Source	**df**	**SS**	**MS**	**F**	**p**
Between groups	2	368872.46	184436.23	.332	.720
Within groups	47	26148129.54	556343.18		

At station #3 the mean error of estimates for the anesthesia group was 621.67 ml (table 4), compared to 588.24 for the surgeons, and 736.67 for the O.R. nurses. There was not a significant difference in the error in estimates between the three groups (p=.588).

TABLE 4
Summary of ANOVA Between Specialty Groups on Accuracy of Estimating Blood Loss at Station #3

Groups	number of subjects	mean	standard deviation		
Anesthesia	18	621.67	535.10		
Surgeons	17	588.24	328.41		
O.R. Nurses	15	736.67	354.86		
Source	**df**	**SS**	**MS**	**F**	**p**
Between groups	2	190617.61	95308.80	.536	.588
Within groups	47	8353280.39	177729.37		

The mean total error of estimates at all three stations was 2438.94 ml (table 5) for the anesthesia group, while the surgeon group had a mean error of 2509.12 ml, and the operating room nurse group had a mean of 2755.00 ml. The total errors in estimations did not differ significantly between groups (p=.581).

TABLE 5
Summary of ANOVA Between Specialty Groups
on Accuracy of Estimating Blood Loss
Total of All Three Stations

Group	number of subjects	mean	standard deviation		
Anesthesia	18	2438.94	1077.43		
Surgeons	17	2509.12	645.62		
O.R. Nurses	15	2755.00	891.63		
Source	df	SS	MS	F	p
Between groups	2	877885.07	438942.54	.550	.581
Within groups	47	37533862.71	798592.82		

<u>Overestimates versus underestimates</u>

Chi-square analysis were used to determine if there was a relationship between the specialty groups and their tendency to over or underestimated. Tables 6,7,8 & 9 summarize the chi square results.

At station number one where the actual amount of blood was 600 ml (table 6), 58.8% of those in group I (anesthesia) overestimated, and 41.2% underestimated. Of those in group II (surgery), 50% overestimated, and 50% underestimated. Of those in group III (operating room nurses), 35.7% overestimated while 64.3% underestimated. There was not a significant relationship between the specialty groups and their tendencies to over or underestimate (p=.797). There were three exact estimates made (one member in each group) at station #1.

TABLE 6
Over-Underestimates by Specialty Group
at Station #1
(n=47)*

	Anesthesia		Surgeons		O.R. Nurses	
	n	%	n	%	n	%
Estimates						
Overestimate	10	58.8	8	50.0	5	35.7
Underestimate	7	41.2	8	50.0	9	64.3
Totals	17	100	16	100	14	100
df = 2	X2 = 1.652			p = .438		

*The three exact estimates were removed for this analysis.

At station number two where the actual amount of blood was 3450 ml (table 7), 100% of those in group I underestimated. Of those in group II, 5.8% had overestimated, and 94.2% underestimated. Of those in group III, 6.7% overestimated, and 93.3% underestimated. None of the subjects had an exact estimate. At station two it is obvious that all provider groups tended to overestimate.

TABLE 7
Over-Underestimates by Specialty Groups
at Station #2
(n=50)

	Anesthesia		Surgeons		O.R. Nurses	
	n	%	n	%	n	%
Estimates						
Overestimate	0	0	1	5.8	1	6.7
Underestimate	18	100	16	94.2	14	93.3
Totals	18	100	17	100	15	100

At station number three where the actual amount of simulated blood loss was 1400 ml (table 8), none of the subjects had an exact estimate. Of those in group I, 33.3% overestimated, while 66.7% underestimated. Of those in group II, 41.2% overestimated while 58.8% underestimated. Of those in group III, 26.7% overestimated while 73.3% underestimated. There was not an association between the specialty groups and their tendencies to over and under estimate (p=.685).

TABLE 8
Over-Underestimates by Specialty Group
at Station #3
(n=50)

	Anesthesia		Surgeons		O.R. Nurses	
	n	%	n	%	n	%
Estimates						
Overestimate	6	33.3	7	41.2	4	26.7
Underestimate	12	66.7	10	58.8	11	73.3
Totals	18	100	17	100	15	100

df = 2 X2 = .76 p = .685

When inspecting all of the estimates made at all three stations by all of the subjects in each group, three of the subjects had exact estimates. A chi square analysis was run on the remaining over and under estimates. Of those in group I, 30.2% overestimated, and 69.8% underestimated. Of those in group II, 32.0% underestimated while 68.0% overestimated. Of those in group III, 22.7% overestimated while 77.3% underestimated. There was not a significant relationship between the variables (p=.579).

TABLE 9
Over-Underestimates by Specialty Group
at All Stations
(n=147)*

	Anesthesia		Surgeons		O.R. Nurses	
	n	%	n	%	n	%
Estimates						
Overestimate	16	30.2	16	32.0	10	22.7
Underestimate	37	69.8	34	68.0	34	77.3
Totals	53	100	50	100	44	100

df = 2 X2 = 1.092 p = .579

* Each of the 50 subjects had 3 estimates for a total of 150 observations. The 3 exact estimates were removed for this chi square analysis.

Covariates as confounding variables

The potential confounding effects of educational level, and years of clinical experience were controlled by the use of analysis of covariance. Level of education and years of clinical experience were entered as covariates. The data collected from the subjects for educational level was collected as "highest degree received", this was converted into years of education in the following manner; high school to zero years; associate to two years; diploma to three years; baccalaureate to four years; doctorate to six years; and medical to eight years.

There was not a significant difference at any of the stations when the years of clinical experience, and the years of education after high school were controlled for (all p values were > .05). Tables 10 and 11 reveal the data for these ANCOVA's.

TABLE 10
Summary of Analysis of Covariance
on Accuracy of Estimating Blood Loss
Among Specialty Groups by
Years of Clinical Experience
(covariate is years of clinical experience)

Source	SS	df	MS	F	p
Station #1					
Covariate (years of experience)	17689.98	1	17689.98	.88	.352
Main effects (group)	768.34	2	384.17	.02	.981
Within (error)	919691.85	46	19993.30		
Total	938150.18	49	19145.92		
Station #2					
Covariate (years of experience)	923557.00	1	923556.60	1.68	.202
Main effect (group)	261318.00	2	130659.16	.24	.790
Within (error)	25332127.00	46	550698.42		
Total	26517002.00	49	541163.31		
Station #3					
Covariate (years of experience)	130192.38	1	130192.38	.72	.400
Main effect (group)	126908.15	2	63454.08	.35	.705
Within (error)	8286797.46	46	180147.77		
Total	8543898.00	49	174365.26		
Total Stations					
Covariate (years of experience)	1413333.00	1	1413332.57	1.78	.188
Main effect (group)	523193.00	2	261596.50	.33	.721
Within (error)	36475222.00	46	792939.63		
Total	38411748.00	49	783913.22		

TABLE #11
Summary of Analysis of Covariance
on Accuracy of Estimating Blood Loss
Among Specialty Groups by
Years of Education
(covariate is years of education)

Source	SS	df	MS	F	p
Station #1					
Covariate (years of education	20825.27	1	20825.27	1.08	.305
Main effects (group)	25982.80	2	12991.40	.67	.516
Within (error)	891342.11	46	19377.00		
Total	938150.18	49	19145.92		
Station #2					
Covariate (years of education)	83813.00	1	83812.56	.15	.703
Main effect (grcup)	289225.00	2	144612.57	.25	.776
Within (error)	26143964.00	46	568347.05		
Total	26517002.00	49	541163.31		
Station #3					
Covariate (years of education	4694.50	1	4694.50	.03	.869
Main effect (group)	640856.81	2	320428.40	1.87	.166
Within (error)	7898346.70	46	171703.19		
Total	8543898.00	49	174365.26		
Total Stations					
Covariate (years of education)	5880.00	1	5879.51	.01	.932
Main effect (group)	1551085.00	2	775542.73	.97	.387
Within (error)	36854783.00	46	801190.93		
Total	38411748.00	49	783913.22		

CHAPTER IV

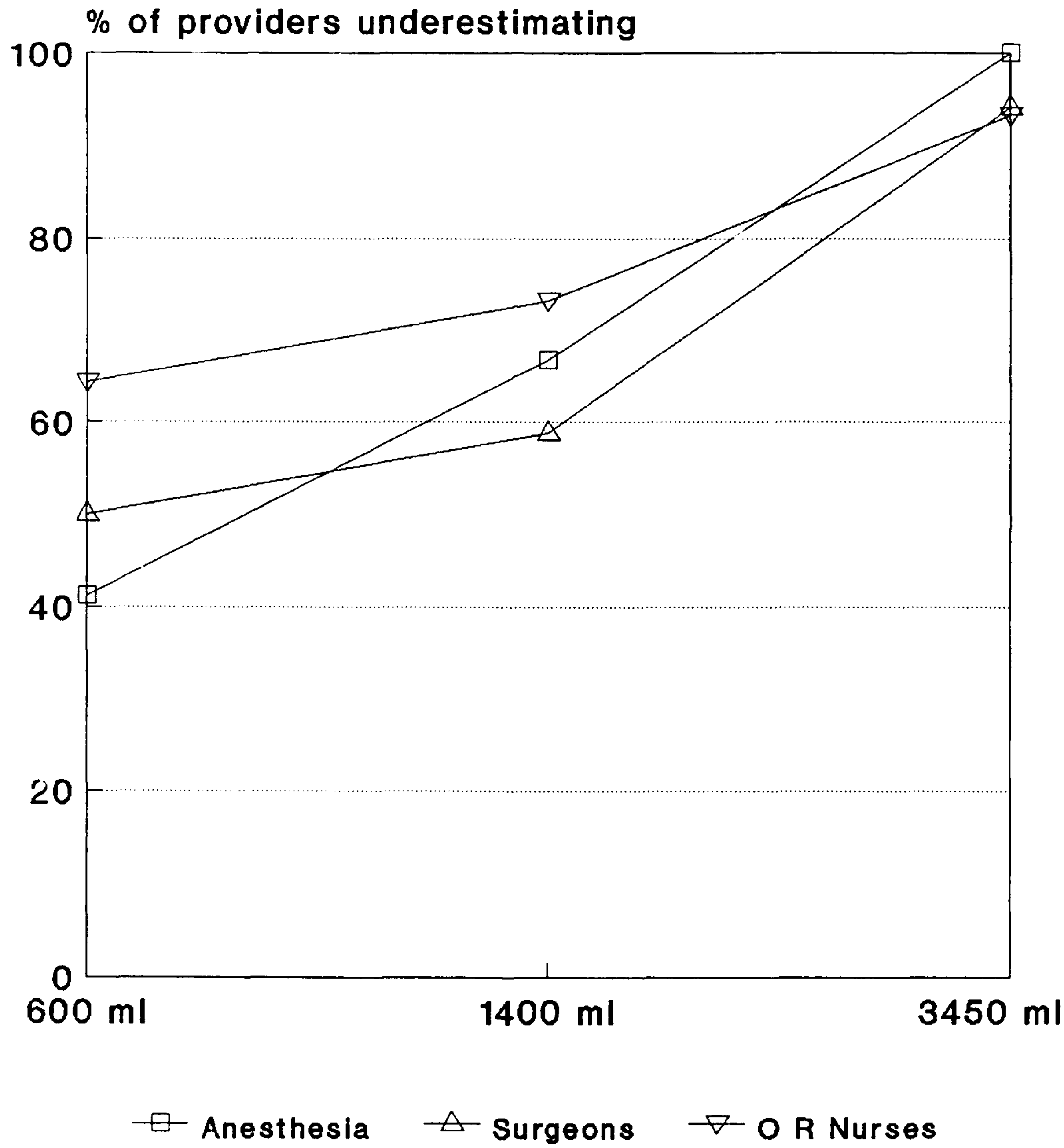
Discussion of Results

The results of this study do not support the hypothesis that there were differences in the abilities of specialties to estimate blood loss within this simulated environment. None of the groups were significantly different from the others in their accuracy to estimate blood loss.

The results are consistent with the literature. Most clinicians are grossly inaccurate at visually estimating blood loss. It is also interesting to note that the mean errors increase as the actual amount of blood increases, indicating that it is more difficult to estimate larger amounts of blood loss. When the actual amount of blood displayed was 600 ml, the mean error was 29% of the actual amount of blood present, compared to a mean error of 46%, when the actual amount displayed was 1400 ml, and a mean error of 50% when the actual amount of blood displayed was 3450 ml. When examining the mean errors at the larger 2 volumes of blood loss, they are close to 50% of the actual amount of blood present.

Seventy percent of the estimates were underestimates, which suggests that most clinicians do indeed underestimate blood loss. This is consistent with the literature. The amounts of overestimating and underestimating were not significantly different among the specialty groups. At the lower level where the actual amount of blood was 600 ml, the under and overestimates were more evenly distributed, 46% overestimated while 48% underestimated. As the amount of blood loss increased the underestimates also increased drastically, to 66% when the blood loss was 1400 ml, and to 96% when the actual amount of blood was 3450 ml (figure 3). As an overall general observation it is clear that, as the amount of blood displayed increased in amount, the errors of the estimates also increased, and tended to be underestimated.

FIGURE 3 Percentage of Providers Who Underestimate Actual Blood Loss



Further research is suggested to determine if this type of relationship exists, and if so to implement a strategy to be applied to clinical practice for clinicians to become more accurate at estimating blood loss. For example, if it is found that, at a 2000 ml operative blood loss the average clinician underestimates by 700 ml, then it can be suggested to add 40% to the clinician's initial estimate. Before these types of suggestions can be made a multifacility study with a large sample size must be completed in order to determine how much of an error occurs at what operative blood loss levels.

The years of clinical experience and the years of education were variables that were thought to be possible influences on estimates made by the subjects. After controlling for these in ANCOVA there still were no significant results. Nominal level data was collected regarding the subjects' education level. This data was converted to ratio level data for this analysis.

This study is consistent with prior studies, however, it can only be generalized to the specialty groups at this particular institution where the study took place. It should also be brought to the readers attention that this study only had a power of analysis at .50. This is interpreted as meaning that the null hypothesis could be correctly rejected 50 times out of 100; ie., if there existed an actual difference among providers and their

ability to estimate blood loss, this study would have a 50% chance of detecting this difference. In order to generalize this type of study to a broader population and to increase the power of this study one should conduct the study at multiple institutions and increase the number of subjects in each group. Another possible limitation in the study was the fact that after about 2 hours during the data collection period, the blood that was displayed began to dry out. It is possible that this may have appeared to the subjects as less blood than was actually there, especially for those who participated late in the study.

Summary

The results of this study support previous studies of the same nature that clinicians, in general, grossly underestimate intraoperative blood loss. Although it may not be the most influential factor in blood replacement therapy, estimation of intraoperative blood loss does play an important role, and it is important for the operating room team to constantly be aware of the progression of blood loss.

No patient should be denied a transfusion if it is clearly indicated. If all clinicians were aware that their estimates were 50% under the actual amount of intraoperative blood loss, would blood replacement therapy be different than what is today? This study suggests that the average clinician will be inaccurately underestimating intraoperative blood loss, especially at the higher limits of blood loss. It is the author's belief that, even if these clinicians were made aware of these types of discrepancies, their strategies for blood replacement therapy would minimally change.

Appendix A

Conceptual & Operational Definitions

accuracy in estimating: The difference of the estimate compared to the actual amount of blood when measuring the actual amount of blood present in ml against the amount of blood visually estimated in ml. or the least error.

actual amount of blood: An exact volume of blood that has been predetermined by the investigator and distributed in a simulated operating room environment.

anesthesia resident: Those physicians who have completed medical school and are currently enrolled in an anesthesia residency program.

anesthesiologists: Those physicians who have completed medical school and have completed a residency in anesthesiology and are currently practicing anesthesia.

estimation: A cognitive process by which an individual subjectively and visually assesses a specific amount of blood in an operating room environment.

group I anesthesia personnel: Anesthesiologists, anesthesiology residents, certified registered nurse anesthetists, student registered nurse anesthetists.

group II surgeons: surgeons and surgical residents

group III operating room nurses: operating room nurses, circulating or scrub nurses.

higher accuracy: Those amounts estimated that are closer to the actual amount of blood present than those estimated amounts that are further from the actual amount

level of education: The highest degree received from an organized teaching institution.

nurse anesthetists: Registered nurses who have completed a nurse anesthesia program and are certified by the American Association of Nurse Anesthetists.

operating room environment: An actual operating room or a simulation of one where a surgery in progress is being simulated. Containing at least an operating room table covered with a surgical drape with blood on it, one to four suction containers with blood and irrigation fluid in them, ten to fifty sponges with blood and irrigation fluid saturated to different degrees, and two to six surgical towels saturated with blood and irrigating fluid to different degrees.

operating room nurses: Those registered nurses who are currently working in the operating room as a circulating nurse or a scrub nurse.

operating room personnel: Any or all of anesthesiologists, anesthesia residents, nurse anesthetists, student nurse anesthetists, surgeons, surgical residents, and operating room nurses.

surgeons: Those physicians who have completed medical school and have completed a surgical residency and are currently practicing surgery.

surgical resident: Those physicians who have completed medical school and are currently enrolled in a surgical residency program.

years of clinical experience: The amount of time one has been working in an operating room, measured in years.

Appendix B

Collection of Data

NAME (optional) ____________________________

1) What is your occupation?

   anesthesiologist
   anesthesiology resident
   nurse anesthetist
   nurse anesthesia student
   operating room nurse
   operating room technician
   surgeon
   surgical resident
   other ______________________

2) What is the highest degree you have received?

   High School
   Diploma
   Associate
   Baccalaureate
   Masters
   Doctorate
   Medical
   other ______________________

3) Write the number of years you have been working in an operating room environment.

   ________years

4) Write your estimation of the amount of blood loss for the appropriate stations.

   station #1 _________milliliters

   station #2 _________milliliters

   station #3 _________milliliters

UNIVERSITY AT BUFFALO
STATE UNIVERSITY OF NEW YORK

Department of Medicine
School of Medicine
Faculty of Health Sciences
Erie County Medical Center
462 Grider Street
Buffalo, New York 14215
(716) 898-3000

May 4, 1990

Robert D. Northern, Jr.
P.O. Box 314
Clarence Center, New York 14032

Dear Mr. Northern:

The proposal "Estimation of blood loss: Comparing the accuracy of operating room personnel" with Mr. Obst has been approved for 12 months by the SUNY School of Medicine and Biomedical Sciences Institutional Review Board. The signed HS-1A form has been sent to the office of Sponsored Programs.

Sincerely yours,

James B. Lee

James B. Lee, M.D.
Professor of Medicine
IRB Chair

JBL/al
cc: Thomas E. Obst

UNIVERSITY AT BUFFALO
STATE UNIVERSITY OF NEW YORK

School of Nursing
709 Stockton Kimball Tower
Buffalo, New York 14214
(716) 831-2510
Fax# (716) 831-2021

May 11, 1990

Mr. Robert D. Northern, Jr.
P.O. Box 314
Clarence Center, New York 14032

Dear Mr. Northern:

Your proposal entitled "Estimation of Blood Loss: Comparing the Accuracy of Operating Room Personnel" has been reviewed and approved for a period of 12 months. At the end of 12 months, approval for continuation of the study must be obtained from the Human Subjects Review Committee. The forms for the continuation review can be obtained from the Committee Secretary.

Please inform the Human Subjects Review Committee if any eventuality should arise with your research which raises additional issues with respect to risks to the subjects and/or confidentiality of the data.

Sincerely,

Gail P. Brown

Gail P. Brown, RN, Ph.D.
Chairperson
Human Subjects Review Committee

GPB:fmg
Enc.
cc-T. E. Obst

References

Blain, A. Impressions resulting from 3,000 transfusions of unmodified blood. Annals of Surgery, 1929, 89, 189.

Bonica, J. J. & Lyter, C. S. Measurement of blood Loss during surgical operations. American Journal of Surgery, 1951, 81, 496-502.

Brockner, J., & Donvig, M. Subjective estimation and electronic determination of operative blood loss. ACTA Anaesthesiology Scandanavian, 1969, 13 (1). 21-24.

Brown, T. K. & Fisk, G.C.. Anesthesia for Children. Witham Essex: Blackwell Scientific Publications, 1979, 133.

Coller, F. A. & Maddock, W. G. Dehydration attendant on surgical operations. Journal of the American Medical Association, 1932, 99, 875-879.

Comeau, P. J. The blood loss analyzer - a new way to estimate blood loss. American Association of Nurse Anesthetists, 1983, 53 (3), 277-280.

Condon, R. Manual of surgical therapeutics (2nd ed.). Boston: Little Brown & Co., 1972.

Delilkan, A. E. Comparison of subjective estimates by surgeons and anesthetists of operative blood loss. British Medical Journal, 1972, 2 (814), 619-621.

Gatch, W. D. & Little, W. D. Amount of blood lost during some of the more common operations. Journal of the American Medical Association, 1924, 83, 1075-1076.

Goodnough, L. T. & Shuck, J. M. Risks options, and informed consent for blood transfusion in elective surgery. The American Journal of Surgery, 1990, 159, 602-609.

Ha, H. C. Estimation of blood loss in the operating room. Canadian Anesthesiologists' Society Journal, 1986, 33 (5), 685.

Higgins, P. G. Measuring nurses' accuracy of estimating blood loss. Journal of Advanced Nursing, 1982, 7 (2), 157-162.

Leveen, H. H. & Rubricius, J. L. Continuous automatic electronic determination of operative blood loss. Surgery, Gynecology and Obstetrics, 1958, 106, 368.

MacLeod, J. H. Estimation of blood loss in a small community hospital. Canadian Medical Association, 1966, 16(3), 114-117.

Miller, R. D. Anesthesia (2nd ed.). New York: Churchill Livingstone, 1986.

Moir D. D., & Wallace, G. Blood Loss of forcepts delivery. British Journal of Obstetrics and Gynaecology, 1967, 74, 424-429.

Nadal, J. W. Blood loss in orthopedic operations. University Hospital Bulletin, Ann Arbor, 1939, 5, 74-78.

National Institute of Health report from the Consensus on Perioperative Red Cell Transfusion. Journal of the American Medical Association, 1988, 260, 2700-2703.

Priano L. L. Trauma. In P. G. Barash, B. E. Cullen & R. K. Stoelting (Eds.), Clinical Anesthesia. Philadelphia: Lippincott, 1989.

Rustad, H. Measurement of operative blood loss. Acta Chirurgica Scandinavica. 1963, 125, 14.

Sherman, L. A. The implications of trends in transfusion. Transfusion, 1988, 28(6), 511-512.

Shoemaker, W. C. & Walker, W. F. Fluid- Electrolyte Therapy in Acute Illness. Chicago: Year Book Medical Publishers, Inc, 1970, 232-233.

Streitz, S. L. Anesthesia for pediatric anesthesia. In Firestone, L. L. (Ed.) Clinical Anesthesia Procedures of the Massachusetts General Hospital, (3rd) ed.). Boston: Little, Brown & Co., 1988.

Surgenor, D. M. Changing patterns of blood transfusions in four sets of United States hospitals, 1980 to 1985. Transfusion, 1988, 28(6), 513-518.

Thornton, J. A. Assessment of fluid loss in trauma and operations and its replacement. In Gray T. C. & Nunn, J. F. (Eds.) General anesthesia (4th ed.). New York: Appleton-Century-Crofts, 1980, 1042-1043.

Wangensteen, O. H. The controlled administration of fluid to surgical patients. Minnesota Medicine, 1942, 25, 783.

Walker. R. H. Transfusion risks. American Journal of Clinical Pathology, 1987, 88 (3), 374-378.

Wallace, G. Blood loss in obstetrics using a hemoglobin dilution technique. Journal of Obstetrics and Gynaecology of the British Commonwealth, 1967, 74, 64-67.

Williams, J. A. & Fine, J. Measurement of blood volume with a new apparatus. New England Journal of Medicine, 1961, 264, 842.

Wilson, R. F. Fluids Electrolytes and Metabolism. Springfield, Illinois: Charles C. Thomas, 1973, 11-15, 106.

Zaglaniczny, K. L. Anesthesia for the trauma patient. In W. R Waugaman et al (Eds.), Principles and Practice of Nurse Anesthesia. Norwalk, Connecticut: Appleton & Lange, 1988.